THE DIVERSE SURFACE COMPOSITIONS OF THE GALILEAN SATELLITES. R. W. Carlson, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109 (rcarlson@lively.jpl.nasa.gov).

The galilean satellites represent a diverse collection, ranging from the volcanic moon Io, with a surface that is changing yearly, to Callisto, with a dark, ancient surface overlying ice. The composition of these surfaces are also quite different due to a variety of processes and influences, including tidal heating, radiolysis, gardening, a magnetic field (Ganymede), and meteoritic infall.

Io's surface contains large quantities of sulfur dioxide (SO_2) and colorful sulfur allotropes, both originating in plumes and flows from the tidally driven volcanoes. A broad, 1-μm band is found at high latitudes and may be due to absorption by long-chain sulfur polymers produced by SO_2 radiolysis, although iron and iron sulfide compounds are candidates. An unidentified 3.15 μm absorber is equatorially distributed while a 4.62 μm band, perhaps due to a sulfate compound, exhibits a non-uniform distribution. Hot spots are generally dark, and some exhibit negative reflectance slopes (i.e., blue). The composition of these lavas has not been established spectroscopically, but the high temperatures of some volcanoes suggest ultramafic silicates or perhaps more refractory material such as oxides.

Europa's icy surface contains the radiolytic product hydrogen peroxide (H_2O_2). This molecule is rapidly destroyed by solar ultraviolet radiation, so replenishment of H_2O_2 by high-energy charged particle impact must be occurring continuously. The same process may produce atmospheric and surficial O_2 and the hydrated compound that was found on Europa, suggested to be hydrated sulfuric acid. The hydrate is observed to be associated with visually dark material, whose spectra resemble sulfur polymers, and with surficial SO_2. A radiolytic sulfur cycle continuously creates and destroys these compounds, and their observed relative abundance agrees with predictions based on laboratory radiolysis experiments. The equilibration time for this cycle is ~ 100 years. Sources of sulfurous material include Iogenic plasma implantation, preferentially deposited on the trailing hemisphere where the hydrated acid, visually dark material, and SO_2 are indeed found to concentrated. Thermal processes such as diapiric heating, accompanied by H_2O sublimation, can further concentrate the sulfur compounds and produce the variegated surface patterns, while gardening and asynchronous rotation modify the global patterns. An alternative suggestion for Europa's hydrate is hydrated sulfate salts from an internal ocean, but the radiolytic lifetime of these compounds at the surface is < 4000 years so they would be rapidly assimilated into the H_2SO_4, SO_2, and S_x cycle. NIMS spectra are best matched with sulfuric acid hydrate. Surficial carbon dioxide is also observed on the leading hemisphere of Europa. This CO_2 may arise from the radiolysis of carbonaceous meteoritic material that is deposited preferentially on the leading hemisphere or it may be an outgassing product.

Ganymede and Callisto are both covered by a dark deposit overlying ice, the latter exposed on ridges, slopes, and within craters. Both satellites show similar spectroscopic features, generally more pronounced in Callisto's spectra. CO_2 is observed to be concentrated on Callisto's trailing hemisphere, suggestive of magnetospheric influence, in particular radiolysis. A corresponding CO_2 atmosphere is found on Callisto. The atmosphere is rapidly depleted by ionization and sweeping, so there must be a continuous source of CO_2 such as radiolysis or outgassing. A band at 3.88 μm has been suggested to be an SH stretch band, but radiolytically-produced H_2CO_3 provides an equally good fit. A 4.57-μm band has been suggested to be from a CN stretch transition but the shape and position is better fit by carbon suboxide (C_3O_2), a radiolysis product of CO_2. Sulfur dioxide has been suggested as a surface constituent on both Ganymede and Callisto based on a 4-μm infrared feature. However, the corresponding feature is not observed on Europa even though an SO_2 ultraviolet feature is present in Europa's trailing side spectra. Ganymede and Callisto's 4-μm feature may represent something other than SO_2.